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52

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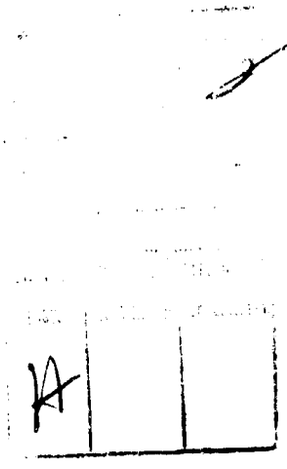

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THE RELATIVE COSTS OF FORMAL AND ON-THE-JOB TRAINING FOR NAVY ENLISTED OCCUPATIONS

Rodney Weiher
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I. Introduction and Objectives

Navy enlisted personnel of pay grades E-4 and above all fall into one of about sixty occupational groups, or ratings. The rating structure covers fields from steward and boatswain's mate, through yoeman to machinist's mate and electronics technician. In order to be promoted to E-4, or third class, in any rating, a man must undergo specialized occupational training to enable him to pass a written examination in the skills that he must master to perform acceptably in the rating for which he is striking.

The Navy provides this specialized training in two ways. About sixty percent of all enlisted men are sent to formal schools--A-schools--for introducory training in their rating. The length of A-school varies from six to thirty-seven weeks, depending on the rating. After finishing school, the men are generally sent to the fleet for a period of on-the-job training (OJT) before taking their third class exam.* Those not sent to A-school go directly to fleet activities where, generally after a period of working on the deck force, or in other generalized occupational groups, they choose a rating in which they want to specialize and learn the skills involved entirely on the job. For some ratings A-school attendance is mandatory for promotion to third class, while others have no A-school. The vast majority, however, have men who have reached E-4 by both the A-school route and via OJT exclusively.

*In some ratings where A-school is especially long and is followed by a class C-school, the graduates are automatically advanced to E-4. In addition, certain honor graduates of some A-school courses are automatically advanced.

The purpose of this study is to determine, in as many ratings as possible:

1. Which major skills can be learned on the job;
2. the ~~time~~ paths of skill acquisition--the learning curves--for non-A-school grads and for A-school grads. This goes one step further than merely determining if a skill can be learned on the job;
3. the relative costs of training third-class petty officers via formal training and ~~OJT~~. This makes it possible to examine whether skills should be taught on the job, once it is known that they can be taught on the job.

The problem was approached by asking the opinions of over 1900 senior enlisted men--men responsible for on-the-job training--about the training process of A-school graduates and non-A-school graduates. From their opinions, embodied in the responses to a carefully designed questionnaire, it was possible to get their estimates of the cost of on-the-job training.

II. The Output of Training

To compare the cost of training an A-school grad with that of training a man who did not attend A-school, it is vital to look at the costs of getting the two men to an equal skill level. That point has been taken to be when the men are, in the opinion of their supervisors, qualified to take the third class exam, on the basis of their on-the-job performance.*

*BuPers requires that a man demonstrate his mastery of the skill before bei allowed to take the 3rd class exam. There is, however, a question of the degree to which this requirement is adhered to at the activity level. The questionnaire implicitly accounts for "Practical Factors" by refering to the point where a man is professionally qualified to take the exam, irrespective of whether he may receive permission before he is qualified.

The third-class exam is administered Navy-wide on a semi-annual basis. This exam is the first one that tests the man's technical achievement in the rating and is taken by both A-school graduates and on-the-job trainees. It therefore provides a unique opportunity to measure the output of the two training paths.

Certain objections could be raised to using the test as a measure of output. Test scores measure the verbal mastery of the subject and may not measure whether the man has mastered the skill in the work environment. They may be biased in favor of "test takers" who probably are over represented in A-schools. Similarly, these test may not measure the Navy's "desired" stock or level of technical skill, since in most cases a third class continues to train on the job. However, the Navy obviously values this test. since it only promotes men who have passed them. This analysis will not be concerned with the validation of the test via job performance measures. It assumes that the Navy knows what it wants out of its third-class petty officers and how to test for it.

However, just because a supervisor thinks a man is qualifed for promotion does not necessarily mean that he can pass the third-class exam. Therefore, the output of the training paths has been measured as actually passing the exam.* To do this, the probability of passing the exam has been accounted for when evaluating the A-school and non-A-school training paths.**

III. The Costs of Training

The expense borne by the Navy in training men to be E-4's may be broken down into several categories.

A. School Costs

Men who attend formal schools entail costs which all OJT trainees avoid. These costs include the cost of operating the schools and the salaries of the trainees while they are in attendance.

*This study used only that portion of the exam that tests technical knowledge of the rating.

**Those men who are automatically promoted without taking the test were excluded from this analysis since they do not appear on the Navy-wide exam results. This exclusion is not serious if the cost of post-school OJT for these men are similar to the regular A school grads.

B. Student Time During OJT

Of course, the salaries and benefits of men (A-school grads or not) undergoing OJT is also a cost of the training process.

C. OJT Productivity

During the period of OJT, trainees do produce useful output. The value of this output must be deducted from the cost of training.

D. Supervisor Costs

An important component of the cost of training a man on the job is the work that must be foregone by the men training him. Thus, if an E-3 takes more senior men in his work area away from their normal work to teach him the skill, he is costing the Navy the value of that undone work.

These supervision costs are exceedingly difficult to quantify. No study, either in the military or in the civilian economy, has successfully estimated them. There is no a priori way to guess them. It is possible that the trainee, acting as a helper, increases the productivity of his instructors. On the other hand, he may require so much help, and slow things down so drastically, as to cost the Navy the output of a whole man, or even more.

It will be shown that the estimates of supervisor cost that were used to evaluate the two training paths crucially affects the conclusions one can draw regarding A-school versus OJT training costs.*

*The cost of any material breakage during training has not been included in this study because of the obvious difficulty of estimating it.

IV. The Study

Most of the data used in this study was gathered via the questionnaire presented in figure 1. The questionnaires were group administered to senior petty officers at Norfolk and San Diego. The sample included men assigned to CVA's, LPH's, SS's, DLG's, AD/AR's, VA/VF squadrons, Naval stations and Naval air stations.

Basically, the men were asked, for their particular rating, to estimate how long it took the average trainee to reach the third-class level, the productivity profile of the two groups of trainees, and the amount of instruction time spent by senior personnel during the training period.

The rest of this section explains how the questionnaire data, and other information, was used to calculate the various costs cited above.

A. School costs were taken from James N. Clary's volume, Training Time and Costs for Navy Ratings and NEC's. (July 1970) These numbers include student pay and allowances (according to the NAVCOMPT cost tables) as well as allowances for such items as accrued leave time.*

B. Estimates of student costs during OJT were inferred from part 2 of the questionnaire. The time the respondants said it took for a student to become qualified to take the third-class exam was multiplied by a pay and allowance figure for E-3's.**

*These costs do not include interest and depreciation costs of buildings and expensive training equipment used in the various A-schools. This leads to a downward bias in the estimates of training costs for A-school graduates, although the magnitude of this bias is not known.

**The pay figures used in this study come from NAVCOMPT personnel cost tables. (FY 1969) Billet cost figures were also used but the results did not change.

Fig. 1

ON-THE-JOB TRAINING QUESTIONNAIRE

CNA USE ONLY	
1 1 2 3 4 5 I.D.	

The following questions are concerned with the on-the-job training that a man receives in his rating or occupational specialty before he is normally qualified to take the Navy-wide 3rd class exam for advancement in rating. The questions refer only to the man's technical or professional skill in the rating, not to the other factors that may determine whether he is advanced, such as minimum time in rate, awards, military, etc.

Information is requested on two separate groups of men striking for 3rd class in the rating. The first group are those men who do not attend A-school, but instead receive their occupational training on-the-job and through correspondence courses (non-A-school). The second group are those men who graduate from the A-school, but then spend some time training on-the-job before they are qualified to take the 3rd class exam (A-school grads).

Gear your answers in terms of the best estimate of the average Navy enlisted man -- not the occasional dullard or crackerjack, but the man of average intelligence and motivation that you usually encounter.

INFORMATION ON RESPONDENT

A. Your rating _ _ _

7-8 B. Your pay grade _ _

10-12 C. Rating to which answers refer. _ _ _ (This should be the same as your rating. If you are especially familiar with another rating, please fill out another questionnaire.)

14-16 D. Type of ship on which you are stationed. If you are at a shore station, please enter SHO. _ _ _

PART 1

1.A How many months of on-the-job training in the rating is required to get a non-A-school man qualified to take the 3rd class examination? Count only the time that the man actively strikes and works in your rating, excluding any time that he spends in the general deck, engineering, etc., force. _ _ months.

1.B How many months does it take an A-school grad who comes to you fresh from A-school to become qualified to take the 3rd class exam? _ _ months.

1.C How many months does it take to get a non-A-school grad up to the professional skill level of a fresh A-school grad? _ _ months.

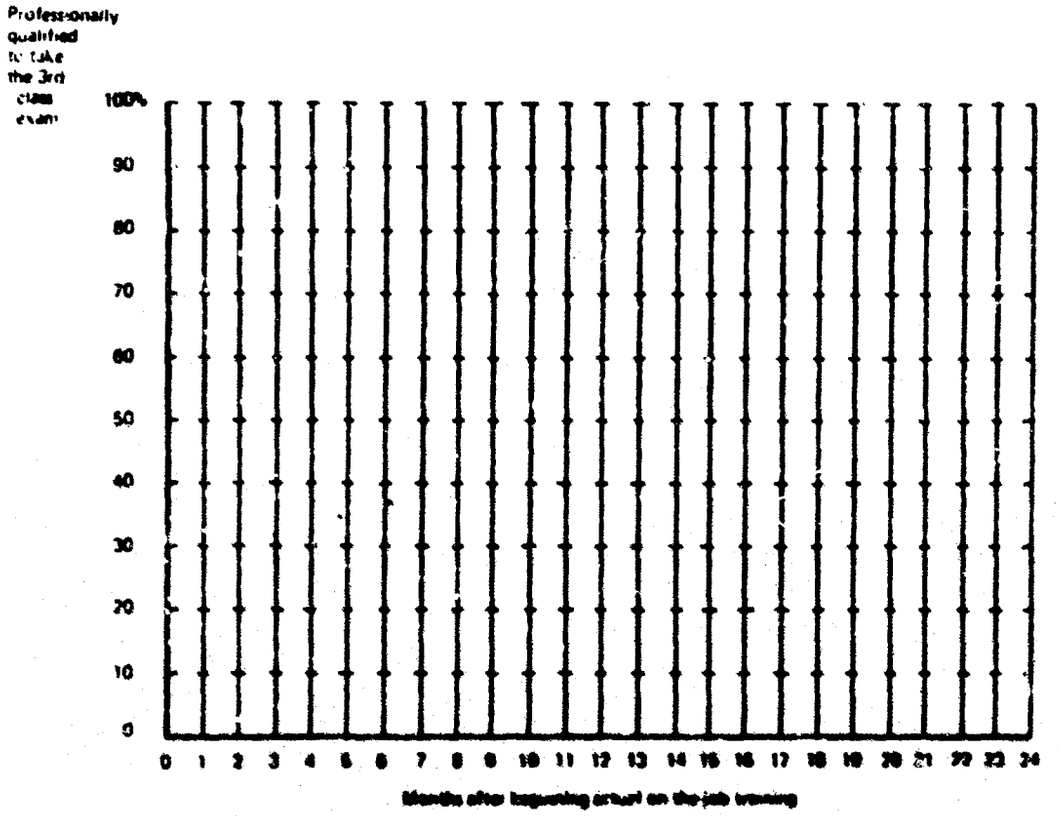
18-20 1.D How professionally proficient, relative to a newly promoted 3rd class petty officer, must a man be before he is qualified to take the 3rd class exam? _ _ _ %.

Fig 1 (cont)

PART 2

In the graphs below, you are asked to indicate how the job skill level of trainees changes at different periods of their on-the-job training when compared to an individual who is qualified to take the 3rd class exam. The vertical axis extends to 100 percent, the point at which the trainee is professionally qualified to take the 3rd class examination. The horizontal axis is divided into one-month intervals.

On the first graph, mark your estimate of how the professional skill of a non-A-school man progresses during training compared to a man qualified to take the 3rd class exam, starting at the time that he strikes for and is working in your rating. Indicate his progress in one-month intervals with an X. The total time period you cover for this should agree with your answer to 1.A above. Make sure you indicate how professionally qualified the man is when he first starts striking and working in your rating by marking the vertical line for zero months.

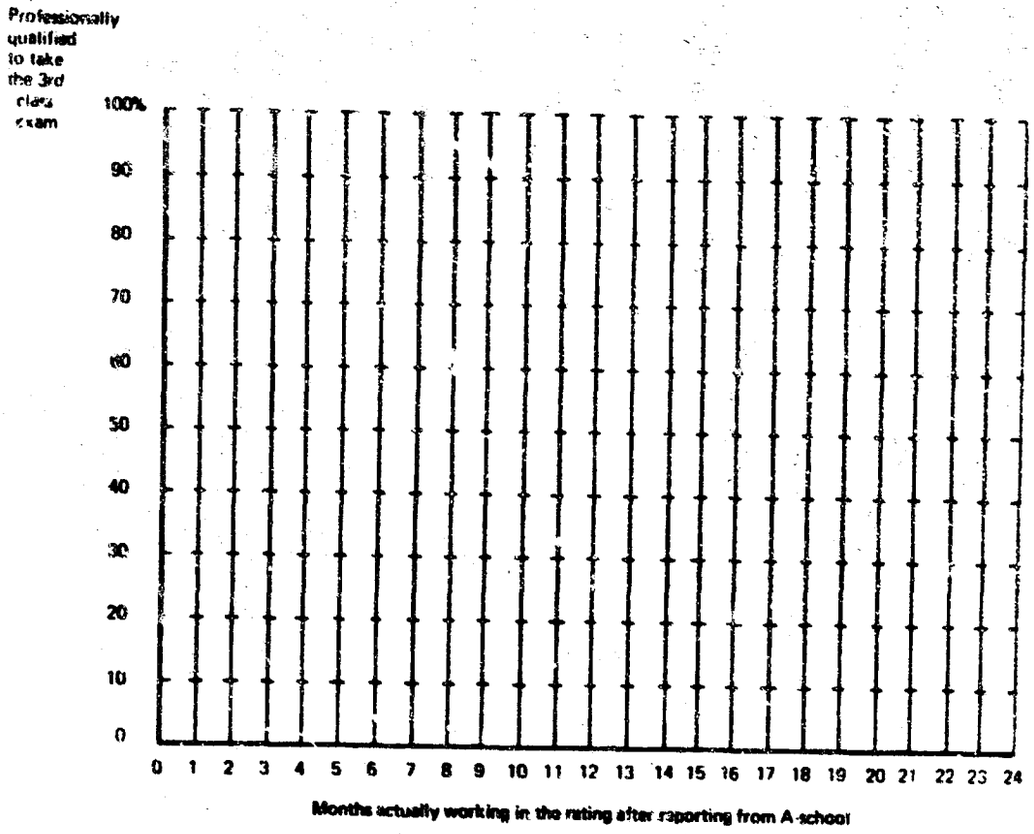


NON-A-SCHOOL TRAINEES

CNR USE ONLY																					
22	23	24	26	27	28	30	31	32	34	35	36	38	39	40	42	43	44	46	47	48
50	51	52	54	55	56	58	59	60	62	63	64	66	67	68	70	71	72	74	75	76
78	79	80				1	2	I.D. 3	4	5	7	8	9	11	12	13	15	16	17	
19	20	21	23	24	25	27	28	29	31	32	33	35	36	37	39	40	41	43	44	45

Fig 1 (cont)

On the next graph, mark your estimate of the change in the professional skill of an A-school grad in one-month intervals, starting with the time he comes to you fresh out of A-school, again compared to a man qualified to take the 3rd class exam. The total time period you cover for this should agree with your answer to I.B above. Make sure you indicate how professionally qualified the man is when he first comes to you by marking the vertical line for zero months.



A-SCHOOL GRADS

CNA USE ONLY																		
	49	50	51	53	54	55	57	58	59	61	62	63	65	66	67	69	70	71
73	74	75	77	78	79			1	2	I.D. 3	4	5	7	8	9	11	12	13
15	16	17	19	20	21	23	24	25	27	28	29	31	32	33	35	36	37	
39	40	41	43	44	45	47	48	49	51	52	53	55	56	57	59	60	61	
63	64	65	67	68	69	71	72	73										

PART 5

CNS USE ONLY

C. The output of a student (either an A-school grad or a non-grad) during OJT was estimated by taking his average proficiency in each month from the relevant graph in part 2 of the questionnaire.* This was multiplied by an E-4's salary. This product was then deflated by multiplying by the answer to question 1D--the man's proficiency relative to an E-4. This gives the dollar value of the man's output in that month. Summing this value over all the months until the man is qualified to take the exam is the estimate of the value of his output during the training period.

D. Supervisor cost was calculated by combining the responses in part 3 of the questionnaire with the time the respondant said it took a man to be able to take the test in part 2. For example, the respondant estimated how much time E-9's lose training OJTer's, both A-school and non-A-school, and the costs to the Navy of this time can be calculated. The same is true for E-8's, E-7's, etc. Therefore it was possible to estimate the value of time (output, productivity) lost because of the need to provide on-the-job training to both A-school grads and non-A-school grads.

These individual components therefore provide estimates of the cost of training men from both paths up to the point where they are ready to take the test. They are cost estimates per <u>test taker</u>. The final step is to convert this to the cost per test passer.

*The questionnaire asked the men to estimate the proficiency of the trainee during the training period, which is defined as the period after the man actively strikes and works in the rating. For non-A-school grads in particular this ignores the period of time that the man spends in non-rated occupations, such as the general deck, engineering, or airmen status. The study assumes that during this period the man is not training for his rating and that no training expenditures are made. Therefore, the useful output that he produces during this time is not deducted from the training cost estimates. In particular, note that this analysis is concerned with marginal changes in the A/OJT pipelines. If in fact, for example, all men were sent to A-school, someone would have to replace the men who spend time in non-rated work, or A-school grads would have to work out of their rating.

E. Mental Ability.

In nearly every rating, A-school grads pass the test at a different rate than non-A school grads. The cost-per-taker could be divided by the actual pass rates to get cost-per-passer. This, however, would not be completely valid. In general, men with higher basic battery test scores are selected to go to A-school and therefore one would expect a higher pass rate from A-school grads.* Therefore, regressions were run of the third class test scores on the four scores in the standard recruit test battery (GCT, ARI, MECH and CLER) for both training paths in every rating. The regression coefficients for each path made it possible to predict the test score that a man who took the exam in August, 1970 would have gotten if he had gone through the other training path. From this it was possible to calculate how likely it would have been that every man, in each rating, would have passed the exam if he had taken the alternative path. That is, estimates were made of how many men in a rating would have passed if they had all gone to A-school, and how many would have passed if none of them had gone to A-school. This corrects each pass rate for the differences in mental ability.

Dividing these pass rates into the previously estimated cost per test-taker yields an estimate of the cost per test-passer for both paths for men of equal intelligence.

V. Results

Table I is of a list of all the enlisted ratings in the Navy. It provides a glossary for the later discussion. Table II shows the number of men who passed the third-class exam via each path in August, 1970. The

*It is possible that the A-schools "teach to the test," which would also lead to higher pass rates for A-school grads. However, the third-class tests are not prepared by the schools, but are made up from the same manuals that are studied by both A and non-A-grads.

information is displayed for all ratings in which A-school is not mandatory and some in which it has recently been made mandatory. A perusal of the table makes it obvious that virtually all Navy specialties can be learned on the job.

The figures following Table II reinforce this belief. They are average learning curves for both A-school grads and non-A-school grads, where the ratings have been aggregated into DOD occupational groups. They come from the individual responses to the questionnaire. Table III lists these major occupational groups and their constituent Navy ratings.

These learning curves indicate that the men who must perform on-the-job training feel that the necessary skills can be taught to a non-A-school grad. As one would expect, the figures show that A-school grads require less OJT than their non-graduate peers and that the men who have finished A-school are more productive during their OJT period. Notice that the senior enlisted men said that it takes longer to train technical ratings such as FT, AT, and MT on-the-job than it did to train men in administrative and non-technical ratings such as YN, QM, and SH. This is reasonable.

The basic results of the analysis are presented in Table IV, by individual ratings. Table V presents summary data aggregated by DOD group. Two primary findings of interest were made. First, except for builder, training costs <u>excluding</u> supervisor costs (school costs plus student pay and allowances minus student OJT output) are always lower

for non-A-school grads than they are for A-school grads. This simply means that if one believes that there are no instruction costs to on-the-job training, only builders should be sent to A-school.* This is illustrated in Table VI, where ratings are ranked in order of increasing A-school non-supervisor cost relative to non-A supervision cost.

Second, except for stewards and torpedomen, total training cost per passer--including the estimates of supervision costs made by the men who supervise--is always lower for A-school grads. This implies that virtually everyone should go to A-school--precisely the opposite of the first finding. Table VII illustrates this by ranking ratings in order of increasing total cost of the A-school path relative to total cost of the non-A-school path.

This reversal is simply because the estimates of supervision costs are such a large fraction of total training cost. In fact, some respondants implied that more than four supervisors were required to train one man. Therefore, all estimates of supervisor time which claimed that each trainee man-day required more than three supervisor man-days were eliminated from these cost calculations. Still, the respondants are knowledgeable in their fields and know more about the actual process of Navy on-the-job training than the authors do. These results reveal the importance of on-the-job supervision and instruction costs, in spite of the difficulty of estimating them.

*The results for builders should not be interpreted strongly since the sample was very small.

The analysis revealed a number of other things. Ratings which have low ratios of A-school supervisor cost to non-A-school supervisor cost need not have low ratios of A-school total cost to non-A-school total costs. This is because ratings which are expensive to teach on-the-job are likely to have expensive A-schools. Table VIII illustrates this. Thus, highly technical ratings--such as FT, ST, and AT are not necessarily among the ratings for which formal school is most beneficial because their school courses are quite expensive.

Having estimated the cost of training men via each of the two existing paths, the cost of training was divided by the number of fully productive months that the Navy could get from its trained personnel. This provides an estimate of training costs per productive month for A and non-A graduates.* The fully productive period was taken to be the remaining portion of a four-year enlistment after the training period, including recruit training.

The learning-curve estimates were used to approximate the length of the OJT period. Of course, the lengths of recruit training and of A-school training are known.

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*The estimates of potential number of months of fully productive labor in this paper are greater than the actual number of months. This is because the Navy initially assigns men to unskilled tasks when they report to fleet activities, especially if they have not been to A-school. This assignment procedure indicates that the Navy feels that getting six months of "deck-force" type duty from these men is more valuable than having them for six extra months as trained rated personnel. Presumably this would be just as true for A-school grads as it is for non-grads. Therefore it would not be fair to consider the extra time non-grads actually spend in this general type duty as shortening their productive period.

The results of this calculation are shown in Table X. Notice that if supervisor costs are assumed to be zero, again, only builders are cheaper to train in school. If the study's supervisor cost estimates are accepted, only torpedomen and stewards are more expensive to train in school. These are precisely the same results mentioned above. Thus the calculation of cost per potential productive month changes none of the earlier conclusions.

The relative training cost estimates in this study can be used by Navy planners as a rough guide to which ratings benefit the most from formal schooling. This is provided in Table VII, referred to above. AE and AQ appear to be the ratings which save the most by sending men to A-school. SD, TM, DK and ST seem to be the best candidates for school closings, if this should be necessary. Since this guide is quite sensitive to the supervisor cost estimates, calculations were made that show the fraction by which these costs could be wrong without making on-the-job training appear cheaper than A-school, for each rating examined. This is shown in Table IX.

VI. Summary and Conclusions.

1. Virtually all ratings can be learned on-the-job.

2. A-school graduates take less time to become proficient in the skill than non-graduates and are more productive during the on-the-job training period.

3. Main results: Although the main results are far from conclusive, the findings have important implications for training policy. First, if the estimates of total training costs are taken, formal schooling appears more efficient for virtually all ratings. Stated another way, if a major portion of the Navy's occupational training is to be shifted to on-the-job training, it must be shown that supervision costs are considerably lower than the estimates made here. This is possible if either the respondants over-estimated the time lost in training on-the-job or if supervision time is worth less than the NAVCOMPT pay tables say it is. If petty officers spend much of their time waiting for contingencies, this waiting time is free to the Navy and it might as well be filled with on-the-job training.

Second, and equally as important, the results should not be taken as conclusive evidence that most ratings should have 100 percent A-school training. If the estimates of supervisor costs are correct, $36 million per test cycle can be saved by sending all men to A-schools. Even though this is a sizeable saving, it is not recommended that an all A-school policy be adopted, because if in fact supervisor costs are zero, such a policy would be $13 million more expensive per test cycle than the current policy. (See Table XI).

The study focused upon a large, but hard to measure element of training cost. On-the-job instruction and supervision costs are rarely accounted for in the same manner as, for example, instructors' salaries in the A-schools. It is recommended that in the future the Navy perform a series of carefully designed time-and-motion studies to determine these costs in any rating for which school expansion is contemplated.

TABLE I

NAVY ENLISTED RATINGS

Abbreviation	Rating
AB	Aviation Boatswain's Mate
ABE	Aviation Boatswain's Mate E (Launching and Recovery Equipment)
ABF	Aviation Boatswain's Mate F (Fuels)
ABH	Aviation Boatswain's Mate H (Aircraft Handling)
AC	Air Controlman
AD	Aviation Machinist's Mate
ADJ	Aviation Machinist's Mate J (Jet Engine Mechanic)
ADR	Aviation Machinist's Mate R (Reciprocating Engine Mechanic)
AE	Aviation Electrician's Mate
AG	Aerographer's Mate
AK	Aviation Storekeeper
AM	Aviation Structural Mechanic
AME	Aviation Structural Mechanic E (Safety Equipment)
AMH	Aviation Structural Mechanic H (Hydraulics)
AMS	Aviation Structural Mechanic S (Structures)
AO	Aviation Ordnanceman Basic
AQ	Aviation Fire Control Technician
AS	Aviation Support Equipment Technician
ASE	Aviation Support Equipment Technician E (Electrical)
ASH	Aviation Support Equipment Technician H (Hydraulics and Structures)
ASM	Aviation Support Equipment Technician M (Mechanical)
AT	Aviation Electronics Technician
AW	Aviation Antisubmarine Warfare Operator
AX	Aviation Antisubmarine Warfare Technician
AZ	Aviation Maintenance Administrationman
BM	Boatswain's Mate
BT	Boilerman
BU	Builder
CE	Construction Electrician
CM	Construction Mechanic
CS	Commissaryman
CT	Communications Technician
CYN	Communications Yeoman
DC	Damage Controlman
DK	Disbursing Clerk
DM	Illustrator Draftsman

TABLE I
(cont.)

NAVY ENLISTED RATINGS

Abbreviation	Rating
DP	Data Processing Technician
DS	Data Systems Technician
DT	Dental Technician
EA	Engineering Aid
EM	Electrician's Mate
EN	Engineman
EO	Equipment Operator
ESK	Telecomm Censorship Technician
ET	Electronics Technician
ETN	Electronics Technician N (Communications)
ETR	Electronics Technician R (Radar)
EW	Electronics Warfare Technician
FT	Fire Control Technician
FTB	Fire Control Technician B (Ballistic Missile Fire Control)
FTG	Fire Control Technician G (Gunfire Control)
FTM	Fire Control Technician M (Surface Missile Fire Control)
GM	Gunner's Mate
GMG	Gunner's Mate G (Guns)
GMM	Gunner's Mate M (Missiles)
GMT	Gunner's Mate T (Technician)
HM	Hospital Corpsman
IC	Interior Communications Electrician
IM	Instrumentman
JO	Journalist
LI	Lithographer
ML	Molder
MM	Machinist's Mate
MN	Mineman
MR	Machinery Repairman
MT	Missile Technician
MU	Musician
OM	Opticalman
OT	Ocean Systems Technician
PC	Postal Clerk

TABLE I
(cont.)
NAVY ENLISTED RATINGS

Abbreviation	Rating
PH	Photographer's Mate
PM	Patternmaker
PN	Personnelman
PR	Airscrew Survival Equipmentman
PT	Photographic Intelligenceman
QM	Quartermaster
RD	Radarman
RM	Radioman
SD	Steward
SF	Shipfitter
SHB	Ship's Serviceman (Barber)
SHL	Ship's Serviceman (Laundry)
SHR	Ship's Serviceman (Cobbler)
SHS	Ship's Serviceman (Clerk)
SHT	Ship's Serviceman (Tailor)
SK	Storekeeper
SM	Signalman
ST	Sonar Technician
STG	Sonar Technician G (Surface)
STS	Sonar Technician (Submarine)
SW	Steelworker
TD	Tradesman
TM	Torpedoman's Mate
UT	Utilitiesman
YN	Yeoman

TABLE II

SUMMARY OF AUGUST, 1970 THIRD CLASS EXAM

Rating	Number of A-School Passes	Takers	Non-A-School Passes	Takers
AB	247	253	386	475
AC	154	179	5	8
AD	1075	1250	240	425
AE	635	802	60	250
AG	77	77	18	21
AK	112	115	166	228
AM	709	725	242	375
AO	535	540	127	158
AQ	183	420	15	38
AS	131	135	53	70
AT	696	991	79	203
AW	92	138	2	14
AX	61	63	6	6
AZ	96	99	96	145
BT	468	470	390	433
BU	25	34	29	49
CE	59	61	17	20
CM	12	24	31	49
CS	356	363	456	493
CT	881	1001	71	118
CYN	359	377	76	82
DC	288	291	125	144
DK	115	129	146	226
DP	182	186	189	211
DS	8	8	4	6
EA	2	3	15	17
EM	414	421	245	318
EN	189	189	543	588
EO	49	66	28	49
ET	249	251	149	172
FT	208	213	65	116
GM	231	235	618	791
IC	235	238	158	174
IM	20	20	5	9
JO	35	36	38	42
ML	12	12	8	9
MM	323	324	610	656
MR	112	115	116	126
MT	4	5	0	0
OM	21	21	3	3
PC	53	55	146	168
PH	92	98	61	90
PM	5	5	4	6
PN	434	461	109	114

TABLE II
(continued)

Rating	Number of A-School Passes	Takers	Non-A-School Passes	Takers
QM	296	303	217	231
RD	607	611	187	212
RM	1234	1277	182	215
SD	2160	3283	259	412
SF	186	186	293	316
SH	32	34	499	529
SK	438	464	601	767
SM	196	196	124	130
ST	182	185	89	99
SW	6	11	13	19
TD	113	115	26	29
TM	209	210	71	79
UT	21	26	8	10
YN	397	404	822	1059

TABLE III

CONSOLIDATION OF TWO DIGIT MILITARY SPECIALTIES

BY DOD OCCUPATIONAL AREA

	OCCUPATIONAL AREA	RATINGS
0.	Infantry Gun Crew and Seamanship Specialists.	BM, QM
1.	Electronic Equipment Repairmen	ST, TM, FT, MT, ET, DS, AV, AT, AX, AQ, TD, OT, CTM,
2.	Communications and Intelligence Specialists	SM, RD, RM, AC, PT, AW, CTI, CTR, CTT,
3.	Medical and Dental Specialists	HM, DT,
4.	Other Technical and Allied Specialists	DM, MU, EA, AG, PH,
5.	Administrative Specialists and Clerks	YN, PN, DP, SK, DK, JO, PC, AK, AZ, CTA, CTO,
6.	Electrical/Mechanical Equipment Repairmen	GM, PI, OM, MM, BT, EM, EQ, AF, AO, AE, PR,
7.	Craftman	LI, MR, SF, DC, PM, ML, CU, CE, EO, BU, SW, UT,
8.	Service and Supply Handlers	CS, SH, SD,

Fig 2
LEARNING CURVE FOR DoD GROUP O
SEAMANSHIP SPECIALISTS

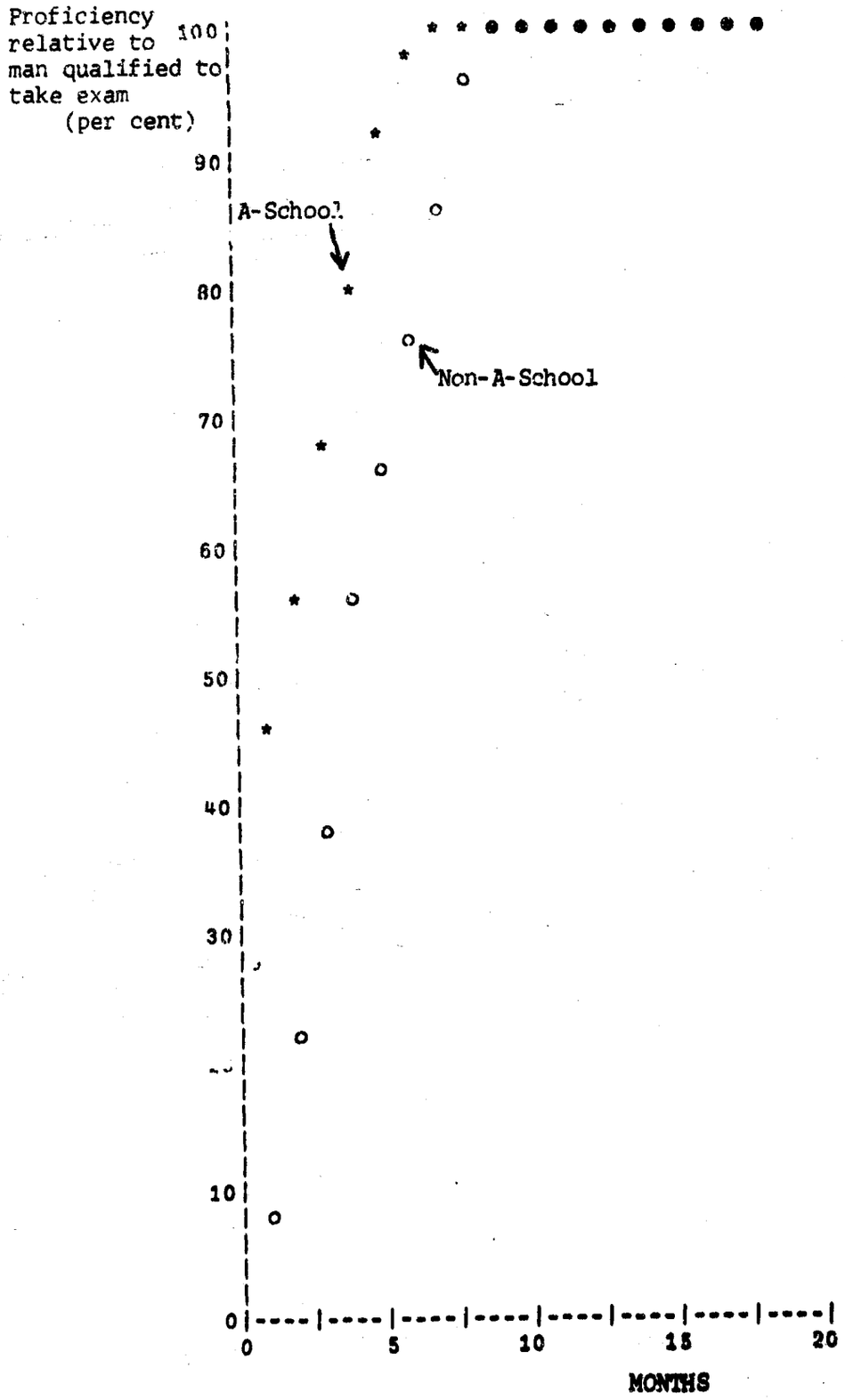

Fig 3

LEARNING CURVE FOR DoD GROUP 1
ELECTRONIC EQUIPMENT REPAIRMEN

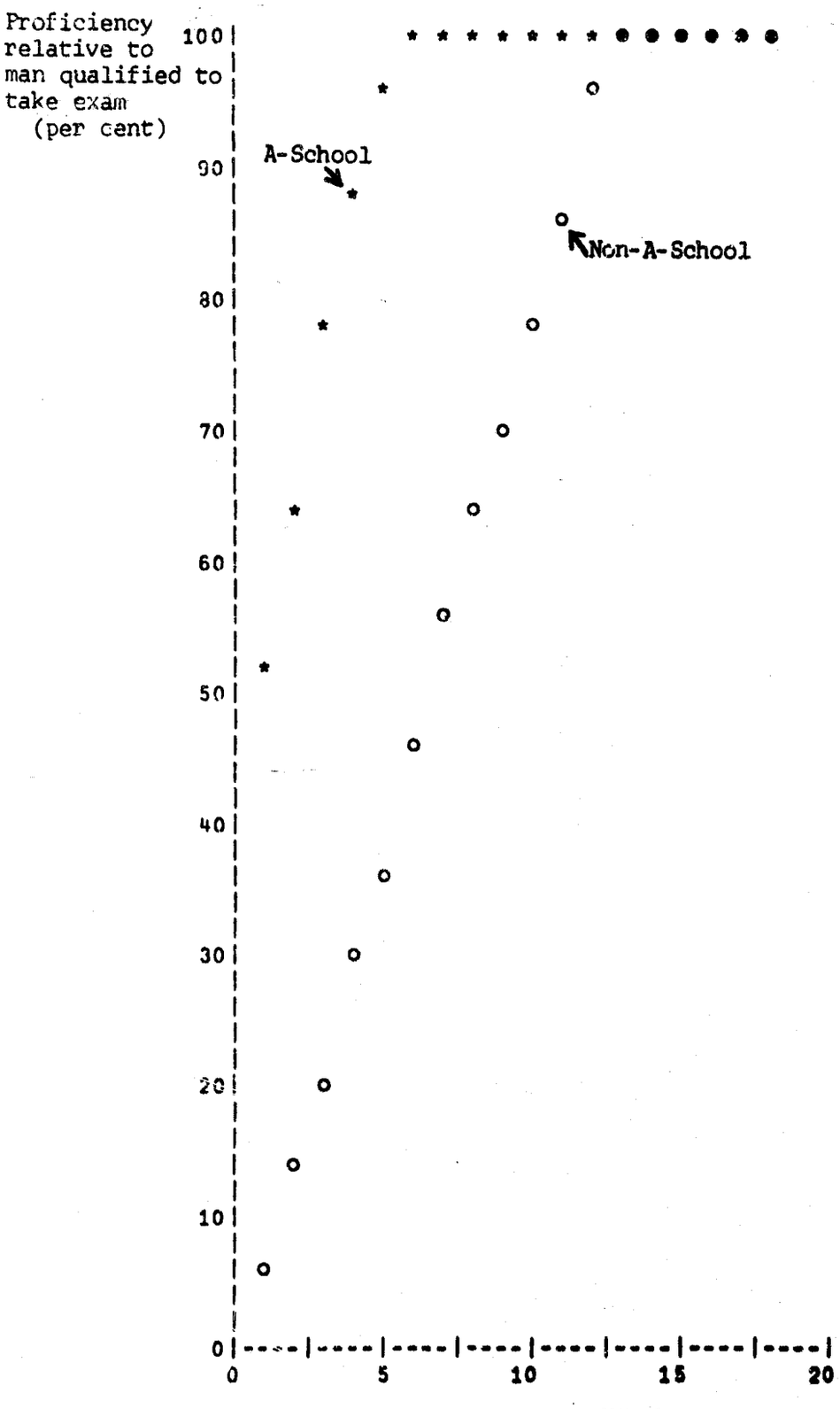

Fig 4

LEARNING CURVE FOR DoD GROUP 2
COMMUNICATIONS AND INTELLIGENCE SPECIALISTS

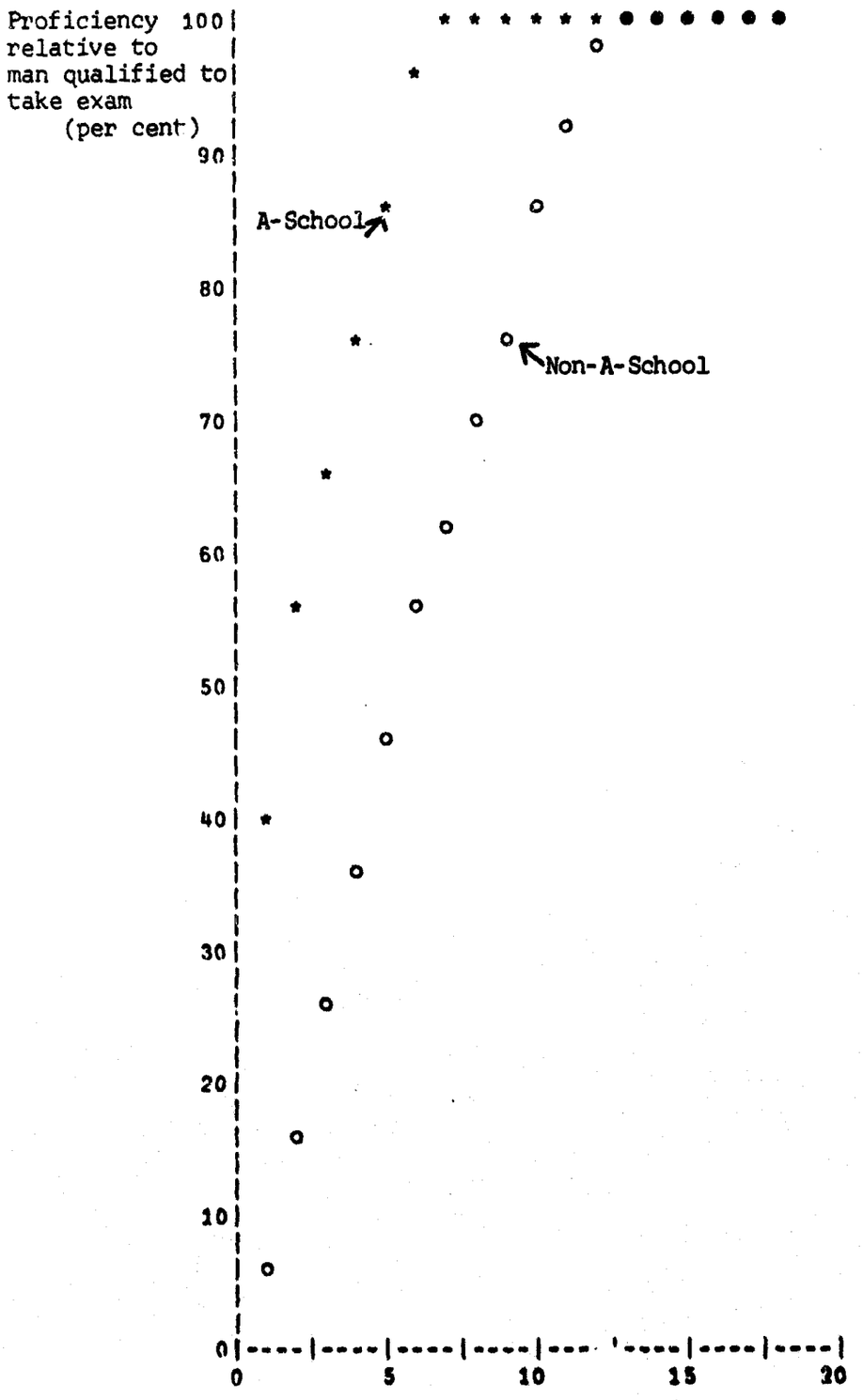

Fig 5

LEARNING CURVE FOR DoD GROUP 4
OTHER TECHNICAL AND ALLIED SPECIALISTS

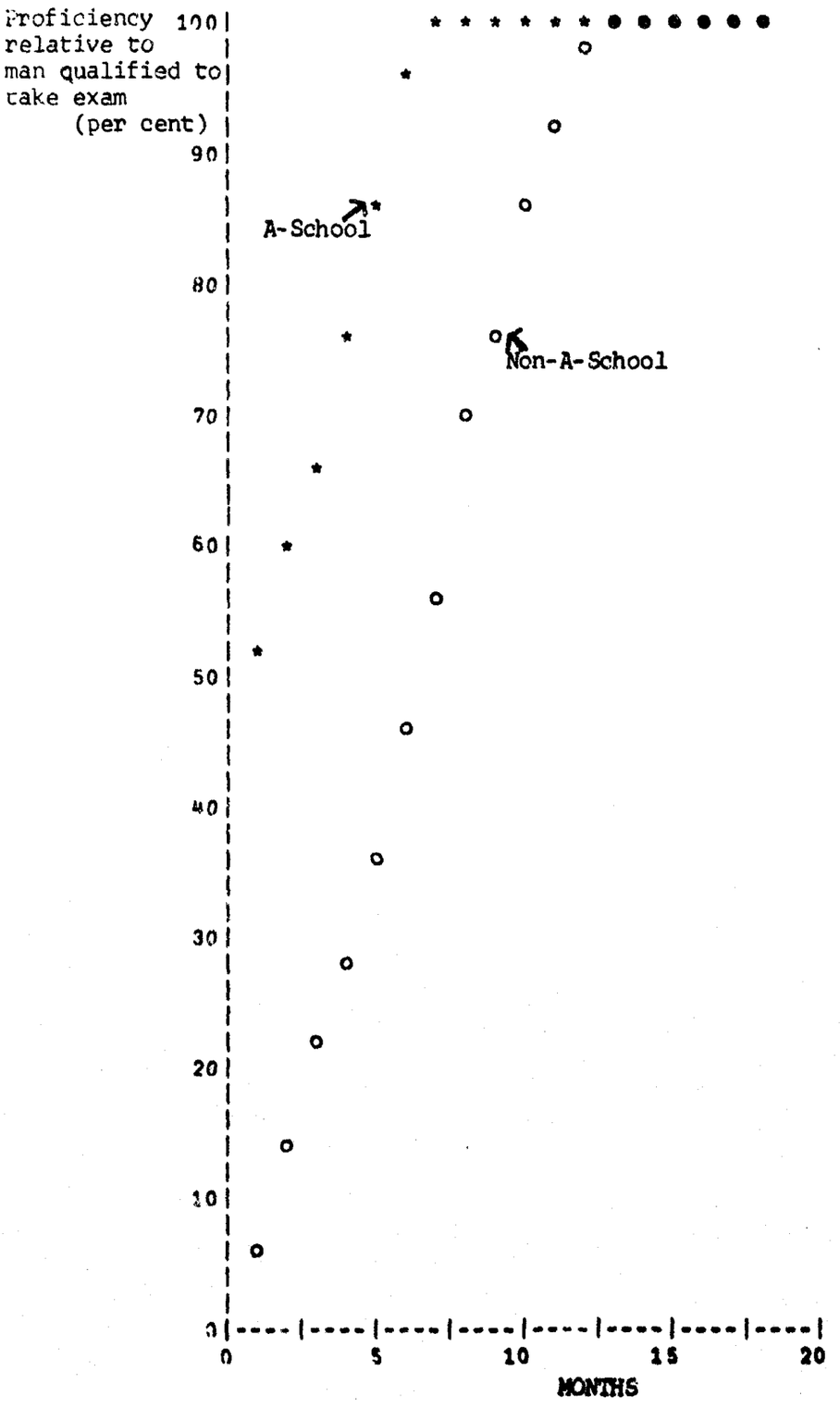

Fig 6

LEARNING CURVE FOR DoD GROUP 5

ADMINISTRATIVE SPECIALISTS AND CLERKS

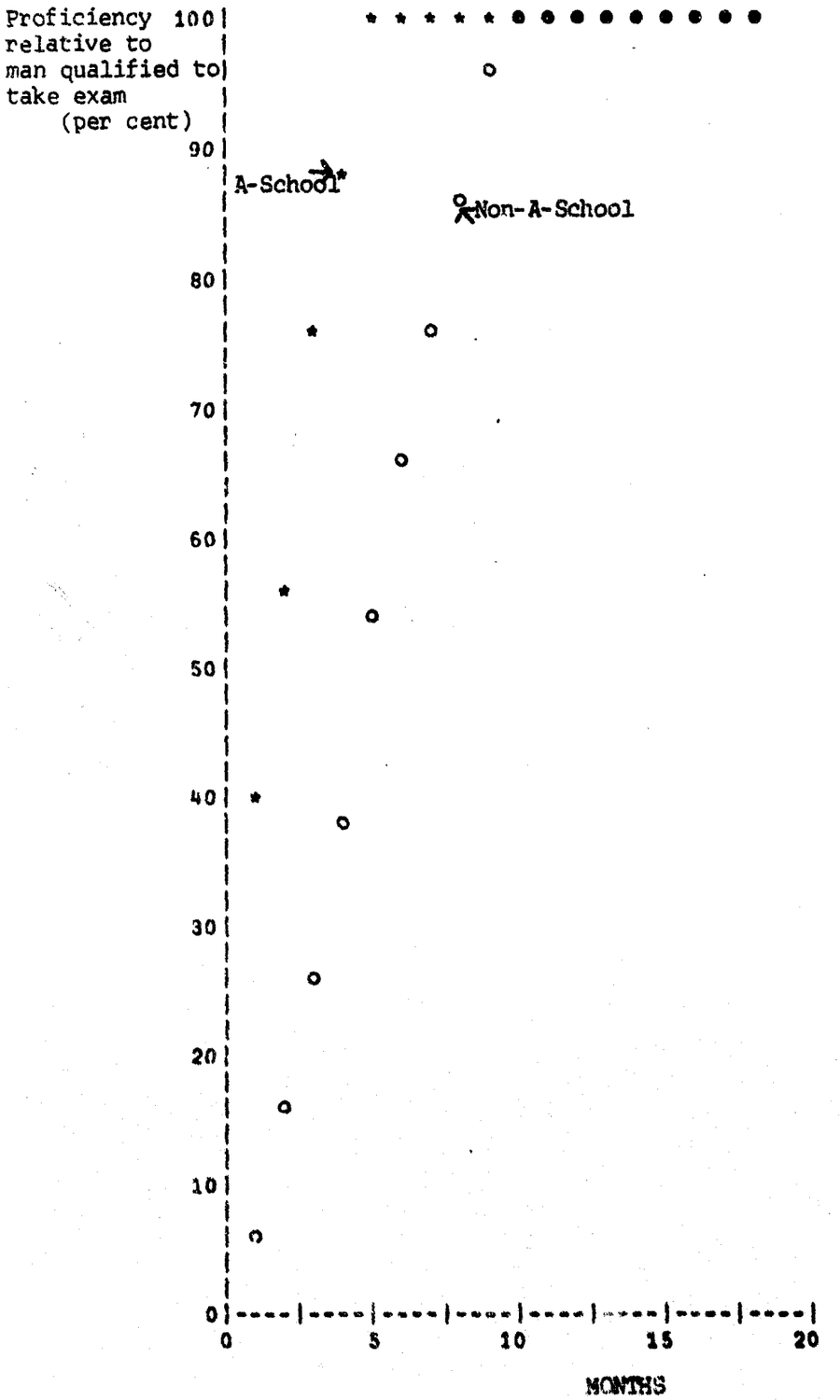

Fig 7

LEARNING CURVE FOR DoD GROUP 6
ELECTRICAL/MECHANICAL EQUIPMENT REPAIRMEN

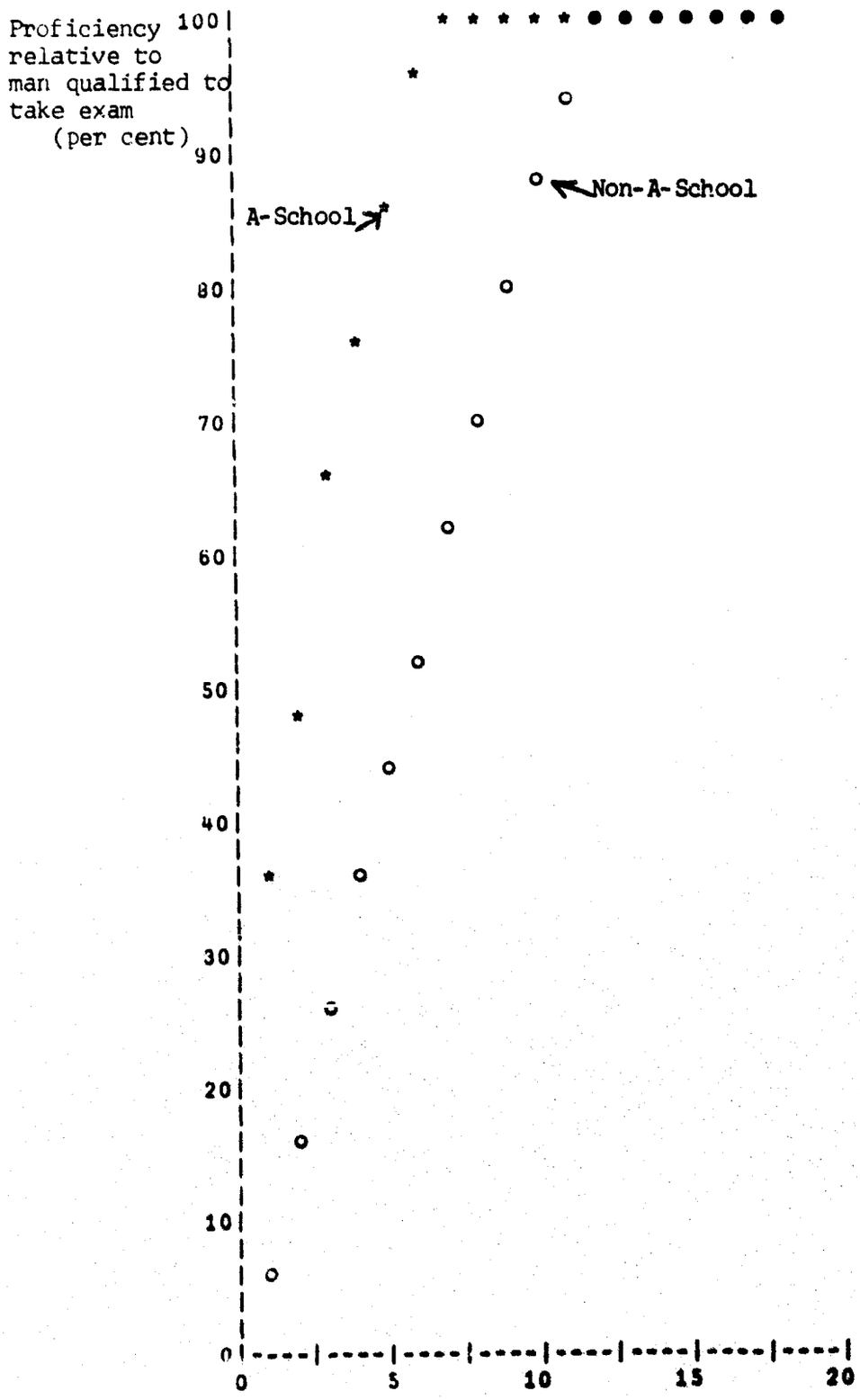

Fig 8

LEARNING CURVE FOR DoD GROUP 7
CRAFTMAN

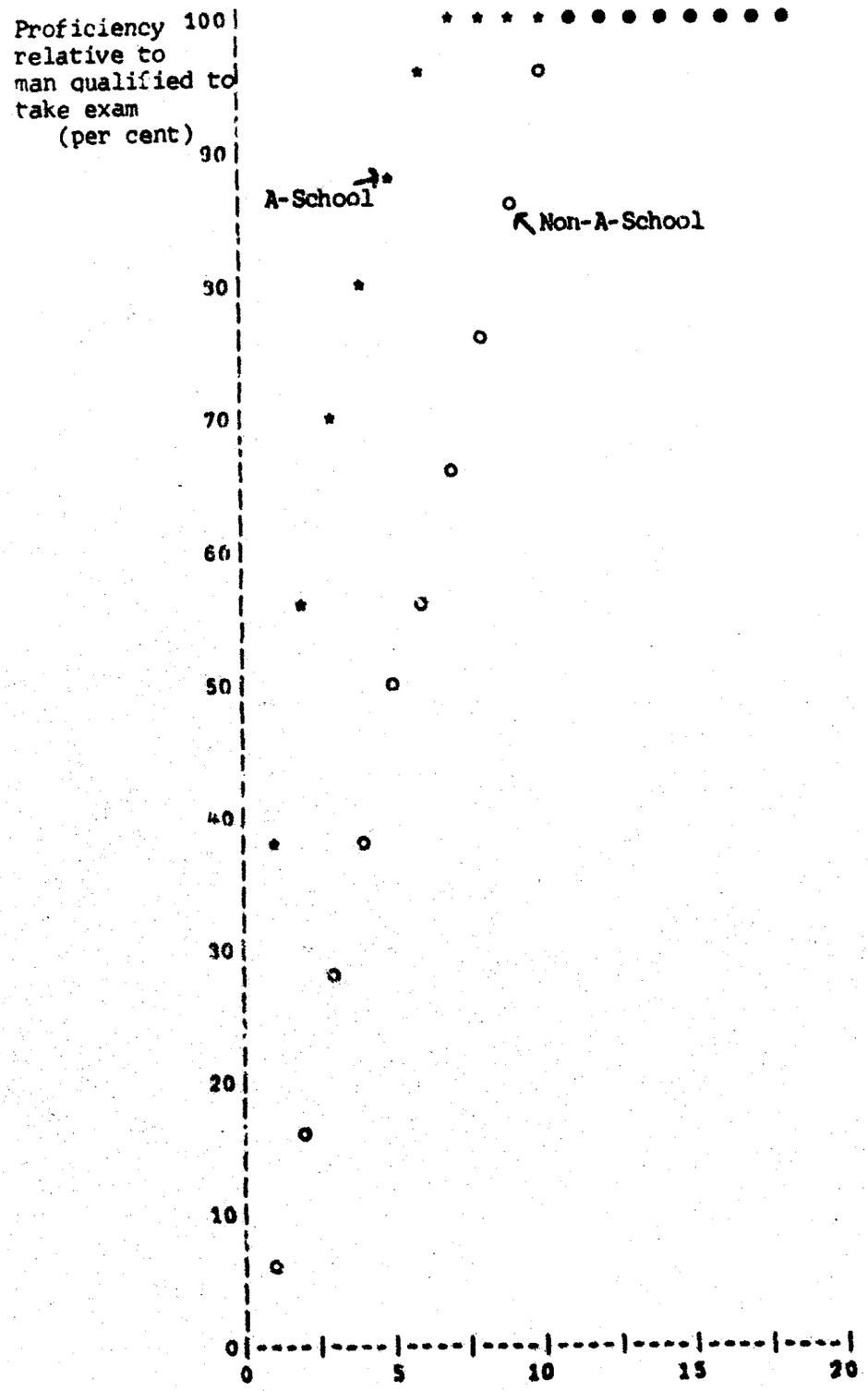

Fig 9

LEARNING CURVE FOR DoD GROUP 8
SERVICE AND SUPPLY HANDLERS

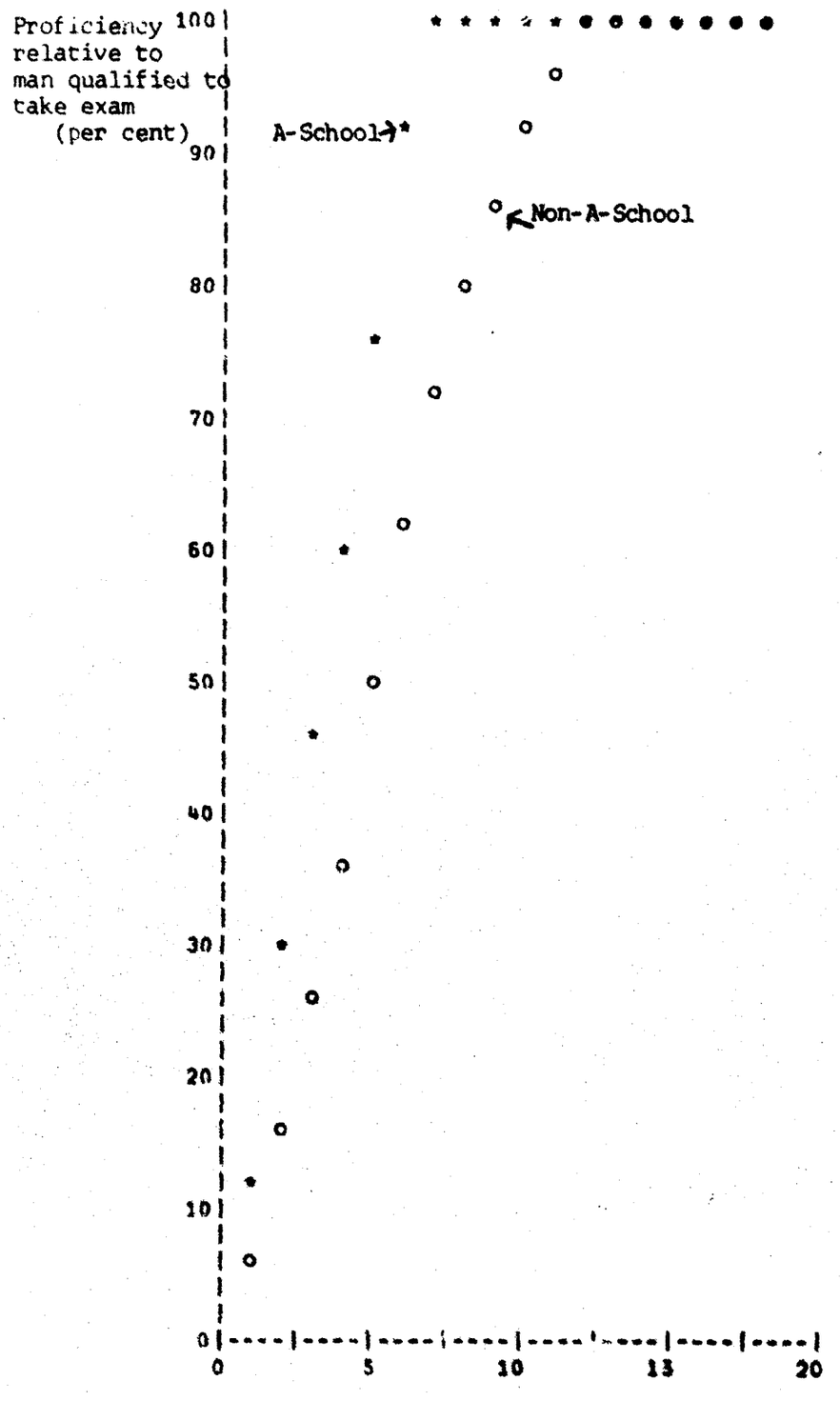

TABLE IV

BASIC COST DATA

(1) Rating	(2) Path	(3) School Cost	(4) OJT Student Pay Cost	(5) OJT Student Output	(6) Total Net Non-Supervisor Cost	(7) # of Observations on Col. (6)	(8) Supervisor Cost	(9) # of Observations on col. (8)	(10) Total Cost Per Test Taker	(11) Corrected Pass Rate	(12) Total Cost Per Test Passer
AB	Non-A	0	2698	1485	1213	27	13913	9	15126	.817	18514
AB	A	1248	1601	1106	1743	27	5060	10	6803	.953	7139
AD	Non-A	0	2760	1852	908	78	7839	36	8747	.676	12939
AD	A	1585	1529	1271	1843	77	4515	45	6358	.862	7376
AE	Non-A	0	3064	1918	1146	66	8800	28	9946	.321	30984
AE	A	2993	1428	1261	3160	67	3841	38	7001	.719	9737
AK	Non-A	0	2648	1623	1025	54	7752	40	8787	.789	11137
AK	A	2074	1154	950	2278	53	3219	45	5497	.960	5726
AN	Non-A	0	2923	1856	1067	83	10115	40	11182	.804	13908
AN	A	2604	1684	1287	2001	91	5476	56	7477	.981	7622
AO	Non-A	0	2768	1641	1127	44	9611	18	10738	.877	12244
AO	A	2102	1199	1046	2255	44	3487	25	5742	.988	5812
AQ	Non-A	0	3707	2566	1141	11	24291	3	25432	.355	71639
AQ	A	6778	1142	1032	6886	15	4206	6	11092	.453	24486
AS	Non-A	0	2980	2225	765	6	11941	3	12706	.911	13947
AS	A	3174	1314	1242	3246	6	5242	4	8488	.977	8688
AT	Non-A	0	1304	101	1203	132	9364	50	10587	.544	19461
AT	A	6778	1306	1196	6886	134	3225	78	10111	.700	14444
AZ	Non-A	0	2197	1366	831	24	7125	18	7956	.749	10622
AZ	A	1349	1067	936	1500	24	3031	22	4531	.977	4638
BA	Non-A	0	2690	1881	809	60	10916	41	11725	.938	12500
BT	A	1828	1571	1525	2274	68	6938	46	9212	.995	9258
BU	Non-A	0	2990	1853	1137	3	2596	2	3733	.502	7436
BU	A	1522	906	835	1593	3	372	2	1965	.738	2663
CS	Non-A	0	2815	1976	839	28	12508	10	13347	.931	14336
CS	A	834	1777	1432	1179	28	6883	12	8062	.988	8160
DC	Non-A	0	2816	1693	923	24	9170	17	10093	.935	10795
DC	A	1283	1506	1219	1570	24	5714	18	7284	.974	7478
DE	Non-A	0	2288	1504	784	12	2407	9	3191	.708	4507
DE	A	1228	1013	746	1495	11	2230	10	3725	.934	3988
DP	Non-A	0	2719	1792	926	5	5168	4	6094	.913	6675
DP	A	2969	1305	1326	2078	5	1318	5	3396	.976	3480
EN	Non-A	0	2929	1878	1053	62	8027	39	9080	.861	10545
EN	A	2013	1649	1427	2240	61	4724	50	6964	.983	7084
EW	Non-A	0	3051	1952	1099	40	9097	25	10196	.936	10893
EW	A	1787	1767	1352	2202	40	5201	30	7403	.957	7425
FO	Non-A	0	2229	1806	623	5	9693	4	10316	.533	19355
FO	A	1784	1631	1435	1980	5	5611	4	7591	.678	196

TABLE IV (cont)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ET	Non-A	0	3550	2225	1321	52	11694	24	13015	.900	14461
ET	A	6730	997	926	6801	51	2647	36	9448	.987	9572
FT	Non-A	0	3608	2130	1478	11	12015	10	13493	.803	16803
FT	A	4619	1903	1566	4956	11	4367	11	9323	.990	9417
GM	Non-A	0	2801	1840	961	23	10149	17	11110	.804	13818
GM	A	2036	1690	1410	2316	23	4970	17	7286	.978	7450
IC	Non-A	0	2905	1742	1163	16	8285	14	9448	.931	10148
IC	A	2772	1410	1088	3094	16	2745	15	5839	.990	5898
JO	Non-A	0	3171	2807	364	3	8670	3	9034	.897	10071
JO	A	1534	1359	1616	1277	3	1512	3	2789	.967	2884
MM	Non-A	0	2762	1723	1039	69	9319	35	10358	.948	10926
MM	A	1886	1747	1306	2327	70	5474	45	7801	.997	7824
MR	Non-A	0	2754	1802	952	23	9842	9	10794	.924	11682
MR	A	1677	1430	1162	1945	23	4102	15	6047	.980	6170
PC	Non-A	0	2073	1411	662	8	4246	6	4908	.868	5654
PC	A	630	1325	1141	814	8	3065	7	3879	.976	3974
PH	Non-A	0	2854	2014	840	26	11699	12	12539	.763	16434
PH	A	3076	1286	1226	3136	26	4157	16	7293	.935	7800
PH	Non-A	0	2508	1522	986	31	4146	27	5132	.956	5313
PH	A	1114	1452	1206	1360	44	2145	43	3505	.942	3721
QM	Non-A	0	2272	1615	657	14	5517	11	6174	.961	6425
QM	A	529	1476	1237	768	14	2925	12	3693	.975	3788
RD	Non-A	0	2678	1625	1053	27	8846	11	9899	.932	10621
RD	A	2747	1718	1355	3110	28	6101	16	9211	.992	9285
RM	Non-A	0	2948	1898	1050	52	10076	34	11126	.931	11951
RM	A	2807	1480	1200	3087	54	4112	40	7199	.964	7468
SD	Non-A	0	3030	2269	761	27	10412	7	11173	.232	48159
SD	A	594	2202	1763	1033	30	7445	12	8478	.155	54697
SF	Non-A	0	2885	1942	943	49	8789	27	9732	.955	10191
SF	A	1680	1698	1384	1994	49	3408	31	5402	.997	5418
SK	Non-A	0	2690	1783	907	48	8931	35	9838	.823	11954
SK	A	1091	1274	992	1373	48	3057	38	4430	.959	4619
SM	Non-A	0	1999	1326	673	17	4890	16	5563	.963	5777
SM	A	793	1443	1141	1095	13	3971	12	5066	.993	5102
ST	Non-A	0	2330	1734	604	20	10160	10	10764	.892	12067
ST	A	6176	1149	1049	6276	22	4202	16	10478	.983	10659
TH	Non-A	0	2542	1616	926	40	7909	15	8835	.964	9165
TH	A	3034	1842	1390	3486	40	6280	24	9766	.986	9905
YH	Non-A	0	2401	1572	829	36	5774	30	6603	.814	8112
YH	A	1114	1253	998	1369	36	2120	35	3489	.988	3531

TABLE V

DATA BY DoD GROUP

(1) DoD Group or Constituent Rating	(2) Path	(3) Non-Supervisor Cost Per Taker	(4) Non-Supervisor Cost Per Passer	(5) Supervisor Cost Per Taker	(6) Supervisor Cost Per Passer	(7) Total Cost Per Taker	(8) Total Cost Per Passer	(9) Ratio of A Cost to Non-A Cost Per Taker	(10) Ratio of A Cost to Non-A Cost Per Passer
0	N	657	684	5517	5741	6174	6425	.598	.590
	A	768	788	2925	3000	3693	3708	.000	.000
QM	N	657	684	5517	5741	6174	6425	.598	.590
QM	A	768	788	2925	3000	3693	3788	.000	.000
1	N	1180	1961	11758	21290	12938	23252	.775	.583
	A	6324	8700	3708	4972	10032	13672	.000	.000
ST	N	604	677	10160	11390	10764	12067	.973	.883
ST	A	6276	6385	4202	4275	10478	10659	.000	.000
TM	N	926	961	7909	8204	8835	9165	1.105	1.081
TM	A	3486	3535	6280	6369	9766	9905	.000	.000
FT	N	1478	1841	12015	14963	13493	16803	.691	.560
FT	A	4956	5006	4367	4411	9323	9417	.000	.000
ET	N	1321	1468	11694	12993	13015	14461	.726	.662
ET	A	6801	6891	2647	2682	9448	9572	.000	.000
AT	N	1203	2211	9384	17250	10587	19461	.955	.742
AT	A	6886	9837	3225	4607	10111	14444	.000	.000
AQ	N	1141	3214	24291	68425	25432	71639	.436	.342
AQ	A	6886	15201	4206	9285	11092	24486	.000	.000
2	N	1003	1074	9044	9689	1 047	10763	.751	.717
	A	2841	2916	4700	4805	7541	7721	.000	.000
SM	N	673	699	4890	5078	5563	5777	.911	.883
SM	A	1095	1103	3971	3999	5066	5102	.000	.000
RD	N	1053	1130	8846	9491	9899	10621	.930	.874
RD	A	3110	3135	6101	6150	9211	9285	.000	.000
RM	N	1050	1128	10076	10823	11126	11951	.647	.625
RM	A	3087	3202	4112	4266	7199	7468	.000	.000

TABLE V (cont)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
IC	N	1163	1249	8285	8899	9448	10148	.618	.581
IC	A	3094	3125	2745	2773	5839	5898	.000	.000
AD	N	908	1343	7839	11596	8747	12939	.727	.570
AD	A	1843	2138	4515	5238	6358	7376	.000	.000
AB	N	1213	1485	13913	17029	15126	18514	.450	.385
AB	A	1743	1829	5060	5310	6803	7139	.000	.000
AM	N	1067	1327	10115	12581	11182	13908	.669	.548
AM	A	2001	2040	5476	5582	7477	7622	.000	.000
AS	N	765	840	11941	13108	12706	13947	.668	.623
AS	A	3246	3322	5242	5365	8488	8688	.000	.000
7	N	924	1082	8817	10136	9741	11218	.626	.581
	A	1826	1955	4271	4557	6097	6512	.000	.000
MR	N	952	1030	9842	10652	10794	11682	.560	.528
MR	A	1945	1985	4102	4186	6047	6170	.000	.000
SF	N	943	987	8789	9203	9732	10191	.555	.532
SF	A	1994	2000	3408	3418	5402	5418	.000	.000
DC	N	923	987	9170	9807	10093	10795	.722	.693
DC	A	1570	1612	5714	5867	7284	7478	.000	.000
EO	N	623	1169	9693	18186	10316	19355	.736	.578
EO	A	1980	2920	5611	8276	7591	11196	.000	.000
BU	N	1137	2265	2596	5171	3733	7436	.526	.358
BU	A	1593	2159	372	504	1965	2663	.000	.000
8	N	789	2436	11156	33715	11945	36151	.697	1.056
	A	1085	4722	7245	33452	8330	38174	.000	.000
CS	N	839	901	12508	13435	13347	14336	.604	.569
CS	A	1179	1193	6883	69 7	8062	8160	.000	.000
SD	N	761	3280	10412	448.	11173	48159	.759	1.136
SD	A	1033	6665	7445	48032	8478	54697	.000	.000

TABLE V (cont)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
4	N	840	1101	11699	15333	12539	16434	.582	.475
	A	3136	3354	4157	4446	7293	7800	.000	.000
PH	N	840	1101	11699	15333	12539	16434	.582	.475
PH	A	3136	3354	4157	4446	7293	7800	.000	.000
5	N	871	1049	6280	7600	7151	8649	.551	.472
	A	1477	1529	2466	2554	3943	4083	.000	.000
YN	N	829	1018	5774	7093	6603	8112	.528	.435
YN	A	1369	1386	2120	2146	3489	3531	.000	.000
PN	N	986	1021	4146	4292	5132	5313	.683	.700
PN	A	1360	1444	2145	2277	3505	3721	.000	.000
DP	N	926	1014	5168	5660	6094	6675	.557	.521
DP	A	2078	2129	1318	1350	3396	3480	.000	.000
SK	N	907	1102	8931	10852	9838	11954	.450	.386
SK	A	1373	1432	3057	3188	4430	4619	.000	.000
DK	N	784	1107	2407	3400	3191	4507	1.167	.885
DK	A	1495	1601	2230	2388	3725	3988	.000	.000
JO	N	364	406	8670	9666	9034	10071	.309	.286
JO	A	1277	1321	1512	1564	2789	2884	.000	.000
PC	N	662	763	4246	4892	4908	5654	.790	.703
PC	A	814	834	3065	3140	3879	3974	.000	.000
AK	N	1025	1299	7762	9838	8787	11137	.626	.514
AK	A	2278	2373	3219	3353	5497	5726	.000	.000
AZ	N	831	1109	7125	9513	7956	10622	.570	.437
AZ	A	1500	1535	3031	3102	4531	4638	.000	.000
6	N	1032	1457	9547	13114	10578	14571	.675	.526
	A	2259	2455	4883	5211	7142	7666	.000	.000
GM	N	961	1195	10149	12623	11110	13818	.656	.539
GM	A	2316	2368	4970	5082	7286	7450	.000	.000
MM	N	1039	1096	9319	9830	10358	10926	.753	.716
MM	A	2327	2334	5474	5490	7801	7824	.000	.000
BT	N	809	862	10916	11638	11725	12500	.786	.741
BT	A	2274	2285	6938	6973	9212	9258	.000	.000
EM	N	1053	1223	8027	9323	9080	10546	.767	.672
EM	A	2240	2279	4724	4806	6964	7084	.000	.000
AO	N	1127	1285	9611	10959	10738	12244	.535	.475
AO	A	2255	2282	3407	3529	5742	5812	.000	.000
AE	N	1146	3570	8800	27414	9946	30984	.704	.314
AE	A	3160	4395	3841	5342	7001	9737	.000	.000
EM	N	1099	1174	9097	9719	10196	10893	.726	.682
EM	A	2202	2209	5201	5217	7403	7425	.000	.000

TABLE VI

TRAINING COSTS FOR NAVY RATINGS
EXCLUDING SUPERVISOR COSTS

Rating	Ratio of A to non-A	A-Costs	Non-A Costs
BU	.953	2159	2265
PC	1.094	834	763
QM	1.152	788	684
AE	1.231	4395	3570
AB	1.232	1829	1485
SK	1.299	1432	1102
CS	1.324	1193	901
YN	1.361	1386	1018
AZ	1.384	1535	1109
PN	1.414	1444	1021
DK	1.445	1601	1107
AM	1.537	2040	1327
SH	1.578	1103	699
AD	1.592	2138	1343
DC	1.633	1612	987
AO	1.776	2282	1285
AK	1.827	2373	1299
EM	1.863	2279	1223
EW	1.881	2209	1174
MR	1.926	1985	1030
GM	1.981	2368	1195
SF	2.025	2000	987
SD	2.032	6665	3280
DP	2.099	2129	1014
MM	2.130	2334	1096
EO	2.498	2920	1169
IC	2.502	3125	1249
BT	2.650	2285	862
FT	2.720	5006	1841
RD	2.775	3135	1130
RM	2.839	3202	1128
PH	3.047	3354	1101
JO	3.254	1321	406
TM	3.681	3535	961
AS	3.956	3322	840
AT	4.448	9837	2211
ET	4.695	6891	1468
AQ	4.729	15201	3214
ST	9.429	6385	677

TABLE VII

TRAINING COSTS FOR NAVY RATINGS
INCLUDING SUPERVISOR COSTS

Rating	Ratio of A to non-A	A-Cost	Non-A Costs
JO	.286	2884	10071
AE	.314	9737	30984
AQ	.342	24486	71639
BU	.358	2663	7436
AB	.386	7139	18514
SK	.386	4619	11954
YN	.435	3531	8112
AZ	.437	4638	10622
PH	.475	7800	16434
AO	.475	5812	12244
AK	.514	5726	11137
DP	.521	3480	6675
MR	.528	6170	11682
SF	.532	5418	10191
GM	.539	7450	13818
AM	.548	7622	13908
FT	.560	9417	16803
CS	.569	8160	14336
AD	.570	7376	12939
EO	.578	11196	19355
IC	.581	5898	10148
QM	.590	3788	6425
AS	.623	8688	13947
RM	.625	7468	11951
ET	.662	9572	14461
EM	.672	7084	10546
EN	.682	7425	10893
DC	.693	7478	10795
PN	.700	3721	5313
PC	.703	3974	5654
MM	.716	7824	10926
BT	.741	9258	12500
AT	.742	14444	19461
RD	.874	9285	10621
SM	.883	5102	5777
ST	.883	10659	12067
DK	.885	3988	4507
TM	1.081	9905	9165
SD	1.136	54697	40159

TABLE VIII

RELATIVE SUPERVISOR COST AND THE COST OF A-SCHOOL

Rating	$\frac{\text{A Supervisor Cost}}{\text{Non-A Supervisor Cost}}$	Cost of A-School
	.097	1522
BU	.136	6776
AQ	.162	1534
JO	.195	2993
AE	.206	6730
ET	.239	2099
DP	.267	6776
AT	.290	3076
PH	.294	1091
SK	.295	4619
FT	.303	1114
YN	.312	2772
IC	.312	1248
AB	.322	2102
AO	.326	1349
AZ	.341	2074
AK	.371	1680
SF	.375	6176
ST	.393	1677
MR	.394	2807
RM	.403	2036
GM	.409	3174
AS	.444	1604
AM	.452	1585
AD	.455	1784
EO	.515	2018
EM	.519	834
CS	.523	529
QM	.531	1114
PN	.537	1787
EN	.559	1886
MM	.598	1283
DC	.599	1828
BT	.642	630
PC	.648	2747
RD	.702	1228
DK	.776	3034
TM	.788	793
SM	1.070	594
SD		

TABLE IX

THE FRACTION BY WHICH SUPERVISOR COST ESTIMATES COULD BE WRONG WITHOUT MAKING OJT APPEAR BETTER THAN A-SCHOOL

Rating	Total cost for Non-A minus total cost for A	Supervisor cost for Non-A minus sup. cost for A	Permissable over-estimate
TM	-740	1835	1.403
ST	1406	7115	.802
AT	5017	12643	.603
RD	1336	3341	.600
ET	4889	10311	.526
DK	519	1012	.487
SH	675	1079	.374
AS	5259	7742	.321
RM	4483	6557	.316
IC	4250	6126	.306
BT	3242	4665	.305
FT	7386	10552	.300
MM	3102	4340	.285
DP	3195	4310	.259
EM	3461	4517	.234
EN	3468	4502	.230
PN	1592	2015	.210
PH	8634	10887	.207
AQ	47154	59141	.203
EO	8158	9910	.177
SF	4772	5785	.175
AK	5411	6485	.166
DC	3316	3941	.159
GM	6369	7541	.156
MR	5511	6466	.148
AO	6432	7430	.134
AD	5563	6358	.125
JO	7187	8102	.113
AM	6286	6999	.102
YK	4580	4948	.074
AZ	5984	6410	.066
CS	6176	6468	.045
SK	7334	7664	.043
PC	1680	1751	.041
QM	2637	2741	.038
AE	21247	22072	.037
AB	11376	11720	.029
BU	4774	4667	-.023
SD	-6537	-3153	-1.073

Table X

Cost of Training Per Productive Month

Rating	Path	Non-Supervisor Cost Per Taker	Non-Supervisor Cost Per Passer	Total Cost Per Taker	Total Cost Per Passer
AB	NON-A	37	45	458	561
AB	A	47	49	183	193
AD	NON-A	26	38	250	370
AD	A	51	59	176	205
AE	NON-A	35	108	301	939
AE	A	94	131	209	290
AK	NON-A	28	36	244	309
AK	A	58	61	141	145
AM	NON-A	32	40	339	421
AM	A	56	57	209	213
AO	NON-A	32	37	307	350
AO	A	62	62	157	159
AQ	NON-A	35	97	771	2171
AQ	A	230	507	370	816
AS	NON-A	23	25	385	423
AS	A	93	96	244	250
AT	NON-A	36	67	321	590
AT	A	246	351	361	516
AZ	NON-A	22	29	209	280
AZ	A	38	39	114	117
BT	NON-A	25	26	355	379
BT	A	66	67	269	270
BU	NON-A	32	63	104	207
BU	A	41	55	50	68
CS	NON-A	25	27	404	434
CS	A	32	32	218	221
DC	NON-A	26	27	280	300
DC	A	43	44	198	203

(Table X, cont.)

Rating	Path	Non-Supervisor Cost Per Taker	Non-Supervisor Cost Per Passer	Total Cost Per Taker	Total Cost Per Passer
DK	NON-A	20	28	82	116
DK	A	38	41	95	102
DP	NON-A	26	29	174	191
DP	A	59	61	97	99
EM	NON-A	32	37	275	320
EM	A	65	66	202	205
EN	NON-A	33	36	309	330
EN	A	62	63	210	211
EO	NON-A	17	32	287	538
EO	A	55	81	211	311
ET	NON-A	40	44	394	438
ET	A	252	255	350	355
FT	NON-A	45	56	409	509
FT	A	160	161	301	304
GM	NON-A	28	35	323	402
GM	A	65	67	205	210
IC	NON-A	35	38	286	308
IC	A	88	89	166	167
JO	NON-A	11	12	274	305
JO	A	34	35	74	77
MM	NON-A	30	31	296	312
MM	A	66	66	221	222
MR	NON-A	29	31	327	354
MR	A	54	55	168	171
PC	NON-A	18	21	136	157
PC	A	22	22	103	105
PM	NON-A	25	33	380	498
PM	A	89	95	207	222
PN	NON-A	27	28	143	148
PN	A	37	39	95	101
QM	NON-A	18	18	167	174
QM	A	20	21	97	100
RD	NON-A	29	31	275	295

(Table X, cont.)

Rating	Path	Non-Supervisor Cost Per Taker	Non-Supervisor Cost Per Passer	Total Cost Per Taker	Total Cost Per Passer
RD	A	93	94	275	277
RM	NON-A	32	34	337	362
RM	A	91	94	212	220
SD	NON-A	22	96	329	1416
SD	A	28	178	226	1459
SF	NON-A	29	30	295	309
SP	A	57	57	153	154
SK	NON-A	27	32	289	352
SK	A	38	39	121	127
SM	NON-A	17	18	143	148
SM	A	28	29	132	133
ST	NON-A	16	18	291	326
ST	A	187	191	313	318
TM	NON-A	26	27	245	255
TM	A	100	101	279	283
TW	NON-A	23	28	183	225
YN	A	36	36	92	93

TABLE XI

THE COST PER TEST CYCLE (6 MOS.) OF
ALTERNATIVE TRAINING STRATEGIES
(millions of dollars)

	If Supervisor Costs = 0	If Supervisor Costs = Study Estimates
Current Strategy	52.4	230.6
All A-school	65.5	193.9
No A-school	26.4	383.7

List of CNA Professional Papers*

PP 1
Brown, George F. and Lloyd, Richmond M., "Static Models of Bank Credit Expansion," 27 pp., 23 Sep 1969, (Published in the Journal of Financial and Quantitative Analysis, Jun 1971) AD 703 925

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Kadane, Joseph B., "Optimal Whereabouts Search," 28 pp., Oct 1969, (Published in the Journal of the Operations Research Society of America, Vol. XIX, 1971) AD 699 515

PP 6 – Classified

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Friedheim, Robert L., "The Continental Shelf Issue at the United Nations: A Quantitative Content Analysis," 25 pp., 7 Jan 1970, (To be published in "Pacem in Maribus," edited by Elaine H. Burnell and Piers von Simson, Center for the Study of Democratic Instructions) (See also PP 28) AD 699 516

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Rose, Marshall, "A Thesis Concerning the Existence of Excess Capacity at Naval Shipyards Prior to the Escalation of Hostilities in Southeast Asia in 1964," 67 pp., 9 Jan 1970, AD 699 518

PP 10 – Classified

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Rose, Marshall, "Study of Reparable Item Resupply Activities," 35 pp., 18 Feb 1970, AD 702 452

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Brown, Lee (Lt., USN) and Rose, Marshall, "An Incremental Production for the End-Item Repair Process," 17 pp., 3 Mar 1970, (Published in Annual Conference of the American Institute of Industrial Engineers Transactions, May 1970, Cleveland, Ohio) AD 702 453

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Rose, Marshall, "Inventory and the Theory of the Firm," 14 pp., 18 Feb 1970, AD 702 454

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Rose, Marshall, "A Decomposed Network Computation for End-Product Repair Curves," 24 pp., 18 Feb 1970, AD 702 455

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Brown, George F.; Corcoran, Timothy M. and Lloyd, Richmond M., "Inventory Models with a Type of Dependent Demand and Forecasting, with an Application to Repair," 4 pp., 10 Feb 1970, (Published in Management Science: Theory Section, Mar 1971) AD 702 456

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Brown, George F. and Corcoran, Timothy M., "The Reliability of a Complex System with Spares, Repair, and Cannibalization," 45 pp., 23 Mar 1970, AD 703 538

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*Department of Economics, Massachusetts Institute of Technology

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CNA Professional Papers -- Cont'd.

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*University of Michigan

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